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# NASA TECH BRIEF

*Ames Research Center*



## Fabrication Techniques for Polybenzimidazole Composites

The performance of polybenzimidazole resin systems and composites as ablative materials has been demonstrated by a series of research programs; more recently, it has been found that performance of polybenzimidazole composites as ablation shields can be substantially improved by thermal crosslinking. To take advantage of the results of the research programs, it was necessary to undertake a program designed to develop new processing methods and techniques for fabrication of polybenzimidazole composites. Since ablation information had only been obtained on laboratory specimens, a concomitant objective of the program was to provide sizable test specimens for a definite evaluation of the ablation behavior of the kind of material which can be produced by typical large-scale polymer production techniques. Although the ultimate objective of the program of investigation was to produce ablative material for heat shields as required by advanced space exploration missions, the techniques developed for fabricating polybenzimidazole composites are directly applicable for nonaerospace uses.

Numerous billets (15.2 x 15.2 cm, up to 5 cm thick) were reproducibly fabricated of a composition consisting of 69% polybenzimidazole, 13% carbon fibers, and 18% phenolic microballoons or glassy carbon spheres. The resin and the fibers were first thoroughly blended and then mixed with the balloons or spheres; preforms were made by light pressing [414 $kN/m^2$(60 psig)] at 250°C and these were further cured and crosslinked under vacuum at a pressure of about 103 $kN/m^2$ (15 psig) at progressively increasing temperatures up to 315°C. The billets were finally postcured at temperatures up to 510°C under nitrogen. Billets formed in this fashion have a density of about 27,680 $kg/m^3$ (30 $lb/ft^3$), a porosity of the order of 45%, and a compressive strength of 13.8 $MN/m^2$ (2000 psi) minimum.

Hollow cylinders about 30 cm long with 1.25-cm walls were fabricated expressly for optimized analysis of the ablative behavior of the polymer composition indicated above. As was described for billets, the cylindrically-shaped polymer composites were preformed in cylindrical molds with pressure applied axially by a cylindrical piston. The preforms were transferred to a specially designed mold for further cure and crosslinking at programmed temperatures under vacuum and gentle pressure. Accurate machining of the cured cylinders was accomplished with the aid of special supporting jigs and mandrels.

Carbon-cloth impregnated composites were made by conventional techniques. Cloth wet with the requisite amount of a 45% solution of polybenzimidazole in tetrahydrofuran was dried in air and then in vacuum at 149°C; a number of plies were laid up, sacked in aluminum foil bags, and cured while compressed under vacuum at temperatures to 510°C. The cured cloth impregnates have densities up to 1.36 g/ml and are suitable as heat shields for reentry systems.

The report which describes in detail the fabrication of polybenzimidazole composites also includes specification and manufacturing standards for the three composites described above.

(continued overleaf)

## Notes:

.1 The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.95)
Reference: NASA CR-1723 (N71-26915), Study and Production of Polybenzimidazole Billets, Laminates, and Cylinders.

2. No other documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California 94035
Reference: B73-10269

## Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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